3.0 Simple Growth Factor Methods

3.1 Introduction

This chapter provides simple methods that can be used to forecast the changes in freight demand due to changes in the level of economic activity or other related factors. The procedure involves applying growth factors to baseline freight traffic data or economic variables in order to project the future freight travel demands. The growth factor approach is classified into two types -- (1) *based on historical traffic trends*, and (2) *based on forecasts of economic activity*. The first approach involves the direct application of a growth factor, calculated based upon historical traffic information, to the baseline traffic data. The second approach recognizes that demand for freight transportation is derived from underlying economic activities (e.g. employment, population, income, etc.). In this approach, forecasts of changes in economic variables are used to estimate the corresponding changes in freight traffic. A hypothetical example is provided at the end of the chapter to illustrate and differentiate the two approaches.

Growth factor methods can be used by State DOT's, MPO's and other planning agencies to establish rough estimates of statewide (or regional) growth in freight traffic for the freight component of a transportation plan. They might also be used to forecast truck travel for pavement design and management. At the local level, these methods might be used to project growth in freight traffic in a given corridor or the level of activity at an intermodal facility.

This chapter also briefly describes a more elaborate alternative approach for freight transportation demand forecasting using statistical techniques.

3.2 Growth Factors Based on Historical Traffic Trends

This section presents a very simple procedure for using historical data for projecting future freight demand. It assumes the availability of at least two years of historical data for the freight demand variable being forecast.

Using two years of historical data, an annual growth factor (AGF) is calculated as follows:

$$AGF = (T2/T1)^{1/(Y2-Y1)}$$

where T1 is freight demand in year Y1 and T2 is freight demand in year Y2.

The annual growth factor can then be applied to predict future demand (T3) for some future year (Y3) as follows:

$$T3 = T2\ AGF^{Y3-Y2}$$

For example, assume that the number of truck trips at a given location on an average weekday was 8,000 in 1990 and 10,000 in 1995. Using this simple procedure, the forecast number of truck trips for the year 2005 is 15,625; i.e.,

$$AGF = (10{,}000/8{,}000)^{1/5} = 1.04564$$

$$15{,}625 = (10{,}000)\ (1.04564)^{10}$$

If more than two years of historical data are available for the variable to be forecast, we suggest that these data be plotted and examined to insure that they exhibit a relatively steady growth rate over time. If the year-to-year changes appear erratic, then the assumption underlying the simple procedure – relatively constant growth rate over time – is called into question.

Particularly for long-range forecasts, using growth factors based solely on historical trends is dangerous because it does not consider the underlying mechanisms or factors that bring about changes in demand for freight. Since freight transportation demand is "derived" from the more basic demands for goods and services, forecasts of various economic factors that affect the demand for goods should be used to predict the corresponding growth (or changes) in freight demand. This procedure is described below.

■ 3.3 Growth Factors Based on Economic Projections

This section presents a simple procedure for forecasting freight using projections of future demand or output for the goods being transported. It also describes various sources of economic forecasts which a freight analyst can use in applying this procedure as well as ways to improve its accuracy. A brief discussion of sensitivity analysis and alternative futures is also included. Most of these discussions were excerpted from the NCHRP 8-30, *Forecasting Freight Transportation Demand*.[1]

3.3.1 Analysis Steps Explained

To simplify the approach for deriving forecasts of future freight traffic from economic forecasts, it can be assumed that the demand for transport of a specific commodity is

[1] NCHRP 8-30 Report - *Forecasting Freight Transportation Demand. A Guidebook for Planners and Policy Analysts*, Cambridge Systematics Inc., January 1996.

directly proportional to an economic indicator variable that measures output or demand for the commodity. With this assumption, growth factors for economic indicator variables, which represent the ratios of their forecast-year values to base-year values, can be used as the growth factors for freight traffic.

This procedure requires data or estimates of freight traffic by commodity type for a reasonably "normal" base year, as well as base year and forecast year values for the corresponding economic indicator variables. The basic steps involved in the process are as follows:

1. Select the commodity or industry groups that will be used in the analysis. This choice is usually dictated by the availability of forecasts of economic indicator variables. As discussed in the next section, much of the available forecasts are by Standard Industrial Classification (SIC) code.

2. Obtain or estimate the distribution of base-year freight traffic by commodity or industry group. If actual data on the distribution are not available, state or national sources may be used to estimate this distribution. For example, the Census Bureau's Truck Inventory and Use Survey (TIUS) provides information on the distribution of truck VMT by commodity carried and industry group. A sample application of TIUS data for this purpose is presented in the example at the end of this section.

3. Determine the annual growth factor (AGF) for each commodity or industry group as follows:

$$AGF = (I_2/I_1)^{1/(Y2-Y1)}$$

   where I_1 is the value of the economic indicator in year Y1 and I_2 is the value of the economic indicator in year Y2.

4. Using the annual growth factor and base-year traffic, calculate forecast-year traffic for each commodity or industry groups as follows:

$$T_f = T_b \, AGF^n$$

   where n is the number of years in the forecast period.

5. Aggregate the forecasts across commodity or industry groups to produce the forecast of total freight demand.

The most desirable indicator variables are those that measure goods output or demand in physical units (tons, cubic feet, etc.). However, forecasts of such variables frequently are not available. More commonly available indicator variables are constant-dollar measures of output or demand, employment, or, for certain commodity groups, population or real personal income. The following subsection describes the data sources for forecasts of some of these economic indicator variables.

3.3.2 Sources of Economic Forecasts

There are several sources which can be used by analysts at State DOT's, MPO's and other planning agencies to obtain estimates of growth in economic activity (by geographic area and industry or commodity type). In general, large urban areas tend to have a smaller growth rate than smaller suburban and rural areas.

Many states fund research groups that monitor the state's economy and produce forecasts of changes in the economy. For example, the Center for the Continuing Study of the California Economy develops 20-year forecasts of the *value* of California products by the two-digit Standard Industrial Classification (SIC) code. Similarly, the Texas Comptroller of Public Accounts develops 20-year forecasts of *population* for ten sub-state regions and 20-year forecasts of *output* and *employment* by one-digit SIC code and sub-state region; and a private firm produces 20-year forecasts of output and employment in Texas by three-digit SIC code. Appendix G lists the data centers in each state.

Long-term economic forecasts also are available from two federal agencies. At 2½-year intervals, the Bureau of Labor Statistics (BLS) publishes low, medium and high 12 to 15-year forecasts of several economic variables, including *real domestic output*, *real exports and imports*, and *employment*, for each of 226 sectors (generally corresponding to groups of three-digit SIC industries).[2] Also, at five-year intervals, the Bureau of Economic Analysis (BEA) develops 50-year regional projections of *population* and *personal income* as well as *employment* and *earnings* by industry sector.[3] The BEA forecasts are published by state for 57 industries, and by metropolitan statistical area and BEA economic area for 14 industry groups (see Appendix K, Part 1).

In addition to the state and federal agencies, short and long-term economic forecasts are also available from several private sources (see Appendix L). The private firms use government and industry data to develop their own models and analyses. Two of the better known private sources are DRI/McGraw Hill and the WEFA Group.

DRI provides national, regional, state, Metropolitan Statistical Area (MSA), and county-level macroeconomic forecasts on a contract or subscription basis. Variables forecast include *gross domestic product*, *employment*, *imports, exports*, and *interest rates*. DRI also produces short-term (2½- to 3-year) and long-term (20- to 25-year) *industrial input* and *output* forecasts for 250 industries (2, 3, or 4-digit SIC code). Industrial inputs include *employment*, *energy*, and *materials* used in production. These input/output forecasts are updated semiannually. *Price* and *wage indices* are also forecast for 650 different industries.

WEFA produces quarterly short (2½ to 3½ year) and long-term (10- and 25-year) and annual long-term (25-year) U.S. macroeconomic forecasts. Variables forecast include *gross*

[2] The most recent BLS forecasts are contained in U.S. Department of Labor, Bureau of Labor Statistics, *American Work Force 1992-2005*, Bulletin 2452, April 1994.

[3] See U.S. Department of Commerce, Bureau of Economic Analysis, *BEA Regional Projections to 2040*, Three Volumes, U.S. Government Printing Office, October 1990.

domestic product, *employment, price indices*, *financial indicators*, and *foreign exchange rates*. WEFA also produces short-term (3 year) *output* forecasts for 537 industries (at the 4-digit SIC level) on a quarterly basis, and long-term (10-year) *input* and *output* forecasts for 480 industries semi-annually.

3.3.3 Improving the Demand Forecasts

The basic procedure presented above makes the simplifying assumption that, for any transport facility, the percentage change in demand for transport (i.e. freight traffic) of each commodity group will be identical to the percentage change in the corresponding indicator variable. However, for various reasons, the two percentage changes are likely to be somewhat different from each other. These reasons include changes over time in:

1. value of output per ton;
2. output per employee;
3. transportation requirements per ton; and
4. competition from other facilities and modes.

To the extent that the likely effects of these changes are understood and can be estimated at reasonable cost, the basic procedure should be modified to reflect these effects. These effects are discussed below.

For most commodity groups, the relationship between *value of output* (measured in constant dollars) and volume shipped (measured in pounds, tons, cubic feet, etc.) may change over time. These changes may be due to a change in the mix of commodities being produced within a given commodity group (e.g., more aluminum and less steel) or a change in the average real value per ton of major products within the group. These changes may result in changing value per ton in either direction. For example, the shift to personal computers from mainframes provides an important example of a product category, computers, in which the value per ton, or per pound, has decreased appreciably. When transport demand is being forecast for several different commodity groups, adjustments for expected changes in value per ton for all commodity groups will be relatively expensive to make and may not have a very significant effect on the overall forecast of transport demand. However, when there are one or two commodity groups that are of particular interest, some consideration should be given, at least in an informal way, to determining how real value per ton for these groups has been changing and how it is likely to change over the forecast period.

Employment is related to transport demand less closely than is real output. Hence, employment is a less desirable indicator variable. However, long-term forecasts of employment are more available than forecasts of output, so that, for some purposes, employment forecasts must be used. As a result of improvements in labor productivity, real dollar-valued *output per employee* increases over time, and physical output (in tons or cubic feet) tends to increase as well. Forecasts of the overall increase in real dollar-valued output per employee for goods-producing industries (agriculture, mining, construction, and manufacturing) can be obtained from DRI/McGraw-Hill. In order to avoid a downward bias in the forecasts of transport demand, forecasts of percentage change in employment should be converted to forecasts of percentage change in (real dollar-valued) output by multiplying by estimated compound growth in labor productivity over the forecast period.

Decreases in the *real cost of transportation* that have occurred over time have resulted in a general tendency for industry to increase its consumption of transport services in order to economize on other factors of production. This tendency has resulted in trends toward decreased shipment sizes and increases in both lengths of haul and standards of service, with the last effect resulting both in a demand for premium quality services (e.g., Just-In-Time Delivery, see Chapter 2) provided by traditional modes and in diversion to more expensive modes that offer faster, more reliable service. Statistical analyses, using procedures such as those presented in Section 3.4 below, should provide useful data for forecasting the extent to which these trends are likely to increase the overall demand for freight transport. However, similar analyses of the secular shift toward higher quality modes are unlikely to produce reliable results because of the difficulty in controlling for temporal changes in modal service quality.

Finally, whenever relevant, forecasts of demand for a facility or mode should be adjusted to reflect expected changes in *degree of competition* from other facilities or modes. These changes may result from:

- expected changes in relative costs;
- the elimination of base-year supply constraints at the facility in question or at competing facilities; or
- the development of future supply constraints at the facility in question or at competing facilities; or
- the development of new competing facilities.

The forecasting problems posed by base-year supply constraints frequently can be avoided by choosing a base year when no significant supply constraints existed. When this is not practical, a combination of historic data and judgment may be used to adjust the estimates of base-year facility usage to eliminate the effects of the supply constraints, thus producing estimates of base-year demand in the absence of supply constraints; annual growth rates or growth factors can then be applied to these estimates of base-year demand to produce the forecast demand.

3.3.4 Sensitivity Analysis

The growth factor methods presented above produce just a single forecast of freight demand. Planning decisions can then be made on the basis of this forecast. However, planners are cautioned that the forecast is likely not to be completely accurate – either because some of the assumptions (e.g., those relating to economic growth) prove to be inaccurate, or because of deficiencies in the procedure itself. Because no forecast can be guaranteed to be perfectly accurate, effective planning requires that planning decisions be reasonably tolerant of inaccuracies in the forecast. The conventional approach to analyzing the effects of alternative futures is to subject a forecast to some form of *sensitivity analysis*.

The development of any forecast requires a number of assumptions to be made, either explicitly or implicitly. Some of the types of assumptions that may be incorporated into forecasts of demand for a transportation facility relate to:

- Economic growth – both nationally and locally;
- Growth in the economic sectors that generate significant volumes of freight handled by the facility;
- Transport requirements of these sectors (which may be affected by increased imports or exports, or by changes in production processes);
- Modal choice (which may be affected by changing transport requirements or changing cost and service characteristics of competing modes);
- Facility usage per unit of freight volume (which may be affected by changes in shipment size or container size);
- The availability and competitiveness of alternative facilities;
- Value per ton of output; and
- Output per employee (if employment is used as an indicator variable).

Sensitivity analysis consists of varying one or more of these assumptions in order to produce alternative forecasts. The most common alternative assumptions to be considered are those related to economic growth; and, indeed, economic forecasters (including BLS) frequently provide high and low forecasts of growth in addition to a medium (or most likely) forecast. These alternative forecasts of economic growth can be used to generate alternative forecasts of transport demand, and additional alternative forecasts of exogenous variables (e.g., trade) can be used to produce an even larger set of forecasts of transport demand (e.g., high growth, high trade; high growth, low trade; etc.) However, simply varying these exogenous forecasts generally will not produce a set of transport-demand forecasts that represents the full range of demand that might exist in future years of interest. To produce a better understanding of the range of demand that might exist in the future, a more thorough sensitivity analysis should be conducted.

One approach to conducting a thorough sensitivity analysis consists of reviewing each of the assumptions explicit or implicit in the analysis and, for each assumption, generating a pair of reasonably likely alternative assumptions, one that would increase the forecast of demand and one that would decrease it. A high forecast of demand can then be generated by using all the alternative assumptions that would tend to increase the forecast (or at least all those that are logically compatible with each other); and a low forecast can be generated by using all the alternative assumptions that would tend to decrease the forecast. These high and low forecasts should provide planners with appropriate information about the range of transport demand that could exist in the future. Planning decisions can then be made that are designed to produce acceptable results for any changes in transport demand within the forecast range.

A somewhat more systematic type of sensitivity analysis consists of making small changes in the analytic assumption, one at a time, and determining the effect of each change on forecast demand. The results of this effort are a set of estimates of the *sensitivity* of the forecast to each of the assumptions. This type of sensitivity analysis can provide more insight into the relationships between the various analytic assumptions and the forecasts produced. However, this approach requires a greater expenditure of resources. Furthermore, the most important sensitivity results – high and low forecasts of demand – can be generated using either approach, though these forecasts will be affected by the alternative analytic assumptions used to generate them and the care with which the high and low forecasts are then generated.

3.4 Alternative Forecasting Methods

One alternative to the use of growth factor methods for forecasting freight travel demand is regression analysis. Regression analysis involves identifying one or more independent variables (the explanatory variables) which are believed to influence or determine the value of the dependent variable (the variable to be explained), and then calculating a set of parameters which characterize the relationship between the independent and dependent variables. For freight planning purposes, the dependent variable normally would be some measure of freight activity and the independent variables usually would include one or more measures of economic activity (e.g. employment, population, income). For forecasting purposes, forecasts must be available for all independent variables. These forecasts may be obtained from exogenous sources or from other regression equations (provided that the system of equations is not circular), or they may be developed by the forecaster using other appropriate techniques.

For forecasting purposes, regressions normally use historic *time-series* data (an alternative is *cross-section* data) obtained for both the dependent and independent variables over the course of several time periods (e.g., years). Regression techniques are applied to the historic data to estimate a relationship between the independent variables and the dependent variable; and this relationship is applied to forecasts of the independent variables for one or more future time periods to produce forecasts of the dependent variable for the corresponding time periods.

The reader is referred to Appendix E of the NCHRP Project 8-30 Report, *Forecasting Freight Transportation Demand*, for a more detailed discussion of regression and other statistical techniques for forecasting freight traffic.

■ 3.5 Illustrative Example

The hypothetical example provided below demonstrates the two approaches for freight demand forecasting using simple growth factors and shows how a freight demand forecast can be refined using information on changes in freight characteristics.

uppose that a 4-lane highway segment in Kentucky serves both passenger and commercial vehicles. The current (e.g. 1995) average daily truck traffic is approximately 8,000 vehicles, or an average of 2,000 vehicles per lane per day. Historical data on truck traffic reveals the following information:

Year	Daily Truck Traffic
1985	3,450
1986	5,270
1987	6,550
1988	6,880
1989	7,130
1990	7,240
1991	7,330
1992	7,500
1993	7,590
1994	7,820
1995	8,000

Suppose that a 4-lane

The Bureau of Census' 1992 Truck Inventory User Survey (TIUS) contains the following information on vehicle miles traveled by all 6-tire trucks and combination vehicles in the United States:

1992 Percentage Distribution of Truck VMT

Source: Truck Inventory and Use Survey, Bureau of Census, 1992.

Major Use	VMT (Millions)	%
Agriculture (Farming)	7,454.9	6.6%
Forestry and Lumbering	2,611.5	2.3%
Mining and Quarrying	1,480.6	1.3%
Construction	13,453.5	12.0%
Manufacturing	8,446.7	7.5%
Wholesale Trade	12,397.4	11.0%
Retail Trade	8,552.3	7.6%
Transportation and Public Utilities	51,180.3	45.6%
Services	6,782.1	6.0%
TOTAL	112,359.3	100.0%

Gross State Product by Place of Work in Kentucky

Source: Bureau of Economic Analysis Regional Projections Through 2045.

Major Use	Gross State Product (Million 1987 $)	
	1992	**2000**
Agriculture (Farming)	2,075	2,357
Forestry and Lumbering	309	456
Mining and Quarrying	3,125	3,888
Construction	2,508	2,838
Manufacturing	15,719	19,671
Wholesale Trade	3,404	4,225
Retail Trade	6,159	7,767
Transportation and Utilities	6,290	7,781
Services	16,255	19,675
TOTAL	55,844	68,658

The Bureau of Economic Analysis' (BEA) forecasts of

For this hypothetical example, it will be assumed that the national distribution of truck VMT shown above is applicable to the State of Kentucky and the highway segment being analyzed. In practice, a more localized or site-specific VMT distribution is preferred to national average since the latter may not fully represent the actual area being analyzed.

ureau of Economic Analysis' (BEA) forecasts of Gross State Product (GSP) for each of these industries in Kentucky are shown in the table below:

Gross State Product (GSP) is the gross market value of the goods and services attributable to labor and property located in a State. It is the State counterpart of the nation's Gross Domestic Product (GDP). Again, for this hypothetical example, it will be assumed that the statewide trends in GSP as presented above are applicable to the highway segment being analyzed. In practice, more localized forecasts should be used.

Determine the total daily truck traffic in the corridor in the year 2000 using both historical traffic growth rate and economic projections. Assume that commodity demand for an industry is directly proportional to the Gross State Product for that industry. In reality, the average price per ton of each commodity may change with time making the above assumption implausible. Furthermore, Gross State Product alone may not be an adequate economic indicator (see Chapter 2 and earlier sections of this Chapter).

A. Historical Trends

Plotting and review of the historical data on truck traffic indicates very large percentage increases from 1985 to 1986 and from 1986 to 1987. In subsequent years, the year-to-year growth is much less. It appears that some occurrence in 1985 or 1986 – perhaps a significant change in the highway network or changes in traffic counting procedures – caused a sharp increase in counted volume on the segment in question. Such an unusual pattern would indicate the need for further investigation. Unless this investigation provides an indication to the contrary, it would seem reasonable to use the 1987 to 1995 growth as the basis for an annual growth factor, since growth during this period was fairly stable.

Forecast of the total truck traffic in the year 2000 is then calculated as follows:

$$AGF = (8{,}000/6{,}550)^{1/(1995-1987)}$$

$$= 1.0253$$

$$T_{2000} = T_{1995}\, AGF^{2000-1995}$$

$$= (8{,}000)\ (1.0253)^{5}$$

Industrial Category	**% VMT**	**Daily Truck Traffic (1995)**
Agriculture (Farming)	6.6%	531
Forestry and Lumbering	2.3%	186
Mining and Quarrying	1.3%	105
Construction	12.0%	958
Manufacturing	7.5%	601
Wholesale Trade	11.0%	883
Retail Trade	7.6%	609
Transportation and Public Utilities	45.6%	3,644
Services	6.0%	483
TOTAL	100.0%	8,000

$$= 9{,}065$$

B. Economic Projections

Following the step-by-step procedures discussed earlier in Section 3.3, the current total daily truck traffic (8,000) is first divided into the various commodity group categories using the truck VMT distribution. As stated above, it is assumed that production of each commodity group, and therefore the freight demand, is directly proportional to the Gross State Product for each commodity category. The results of these two steps are shown in the table below:

Using the BEA forecasts, the average annual growth factor in GSP (and thus the demand for commodities associated with GSP) for the various categories are calculated as shown below (*Step 3*):

Industrial Category	Gross State Product (Million 1987 $)		Annual
	1992	2000	Growth Factor
Agriculture (Farming)	2,075	2,357	1.0170
Forestry and Lumbering	309	456	1.0593
Mining and Quarrying	3,125	3,888	1.0305
Construction	2,508	2,838	1.0164
Manufacturing	15,719	19,671	1.0314
Wholesale Trade	3,404	4,225	1.0302
Retail Trade	6,159	7,767	1.0326
Transportation and Utilities	6,290	7,781	1.0296
Services	16,255	19,675	1.0263
TOTAL	55,844	68,658	

Industrial Category	Daily Truck Traffic (1995)	Annual Growth	Daily Truck Traffic (2000)
Agriculture (Farming)	531	1.0170	577
Forestry and Lumbering	186	1.0593	248
Mining and Quarrying	105	1.0305	123
Construction	958	1.0164	1,039
Manufacturing	601	1.0314	702
Wholesale Trade	883	1.0302	1,024
Retail Trade	609	1.0326	715
Transportation and Public Utilities	3,644	1.0296	4,217
Services	483	1.0263	550
TOTAL	8,000		9,195

For each industrial category, the annual growth factor in GSP is used to forecast the year 2000 truck traffic volume (*Step 4*). For example, the forecast of truck traffic for agriculture/farming is calculated as follows:

Agriculture/Farming:

$$T_{2000} = T_{1995} * (AGF)^{(2000-1995)}$$

$$= 531 * (1.0170)^5$$

$$\cong 577 \text{ trucks per day}$$

Finally, the individual forecasts are aggregated to calculate the total future truck traffic estimated, as shown in the table below (*Step 5*):

Truck traffic forecasts based on historical trends do not provide as much underlying basis as the forecasts shown above. One is therefore more inclined to use forecasts based on economic projections rather than those based on historical traffic projections.

Again, the above forecasts assume that the unit prices of the commodities, or values of output per ton, remain unchanged over time. As explained earlier, this is a very restrictive assumption because unit prices do change with time. In order to improve these forecasts, adjustments must be made based on the historical price variations.

llustrate the adjustment procedure for coal mining, the following data derived from the 1994 U.S. Statistical Abstract will be used:

Price of Bituminous Coal
Source: 1994 U.S. Statistical Abstract

Year	Price per Short Ton (1987 $)	% Change
1987	23.00	
1988	21.13	-8.1%
1989	19.93	-5.6%
1990	18.87	-5.3%
1991	17.89	-5.2%
1992	17.14	-4.2%
Average:		-5.7%

To illustrate the adjustment

The price of coal is dropping but at a decreasing rate. Continuing this trend, we forecast the following prices through the year 2000:

Year	Price per Short Ton (1987 $)	% Change
1993	16.59	-3.2%
1994	16.11	-2.9%
1995	15.73	-2.4%
1996	15.41	-2.0%
1997	15.16	-1.6%
1998	14.96	-1.3%
1999	14.79	-1.1%
2000	14.66	-0.9%

sts for coal mining as part of the general mining and quarrying industrial classification in the State of Kentucky are shown in the following table:

Gross State Product for Mining/Quarrying in Kentucky
Source: Bureau of Economic Analysis Regional Projections Through 2045.

Industrial Category	Gross State Product (Million 1987 $)		Annual
	1992	2000	Growth Rate
Mining and Quarrying			
• Metal Mining	0	0	0.00%
• Coal Mining	2,911	3,649	3.17%
• Oil and Gas Extraction	74	72	-0.24%
• Non-metallic minerals, except fuels	141	167	2.30%
TOTAL	3,125	3,888	3.05%

Forecasts for coal mining as part of the general mining and quarrying industrial

The equivalent tonnage for coal mining can be calculated as follows:

1992 Tonnage = $2,911,000/ ($17.14/ton)
≅ 169,837 short tons

2000 Tonnage = $3,649,000/ ($14.66/ton)
≅ 248,909 short tons

Therefore the more accurate annual growth rate for coal mining truck traffic is:

$= 100\% * ((248{,}909/169{,}837)^{1/8} - 1)$

$\cong 4.9\%$

which is higher than the growth factor of 3.17% used in the earlier calculation.